Your name: ___________________ **Lab section:** M Tu Wed Th F

TA name: _____________________ 8 10 12 2 4

Lab 6. Magnetism

INTRODUCTION

This week we will begin work with magnets and we will look at the interaction between magnetic fields and flowing current. The goals of this lab are to see how magnetism is created by and acts on electrical currents, to learn two ways to use the right-hand rule in magnetism, and to see some real-world examples of magnetism.

PART I: MAGNETIC FIELD PRODUCED BY A BAR MAGNET

In this lab you will be using bar magnets as the source of the magnetic field. The bar magnets each have two poles (North and South), but they are not labeled. Once you determine which end of the magnet is North and which is South, be sure to keep track of it! IMPORTANT: The convention for magnetic field lines is that they point **away** from a magnetic “North” pole, and **towards** a magnetic “South” pole.

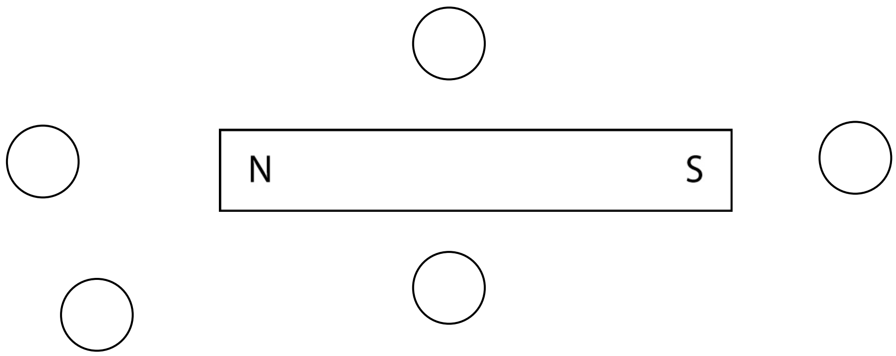
Predict: How does a compass react to a bar magnet? Why?

Explore your predictions using the resources your TA provides.

Revise and expand your ideas:

How does a compass react to a bar magnet? Why?

Suppose each of the circles in the figure below is a compass. In each circle, **draw the way a compass would point** by drawing an arrow in each circle. (The magnetic field of the bar magnet is much stronger than the magnetic field of the Earth, so you can neglect the magnetic field of the Earth in this situation and in all of the following experiments as well).



In the space below, explain how you determined the orientations of the compasses in your drawing above.

PART II: MAGNETIC FIELD PRODUCED BY A CURRENT

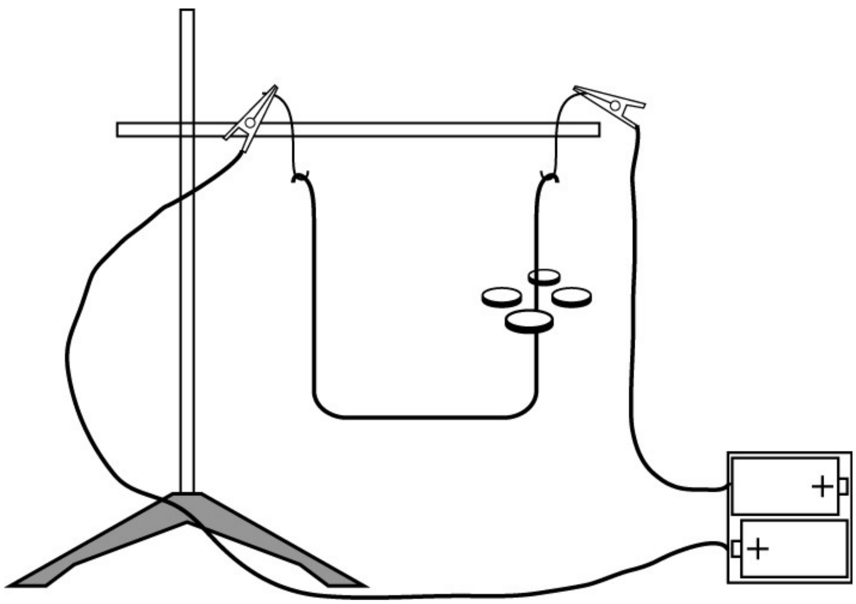
Predict: How can an electric current affect a compass? Why?

Explore your predictions using the resources provided by your TA.

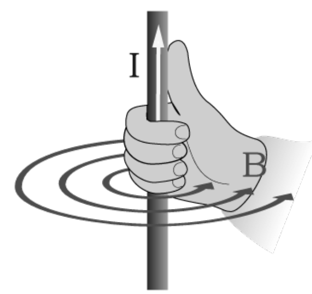
Revise and expand your ideas:

How can an electric current affect a compass? Why?

At your table, you should have the pieces to construct a "trapeze" setup similar to the picture below. **NOTE: After you are done with each measurement, disconnect the battery!** The trapeze should be set up to swing freely – be careful that there is no pressure on the joints that will keep it from moving. On the figure, draw the direction of the current.



The direction of the magnetic field around a current-carrying wire can be determined by the **right-hand rule**. Namely, if you point your thumb in the direction of the current, your fingers will curl in the direction of the magnetic field lines which surround the current. In other words, the direction of the magnetic field around a straight wire carrying a current is a series of circles with a direction that follows the direction of your fingers.



Using the figure above, **predict and draw** the direction of the magnetic field lines in the vicinity of the upper-leg of the trapeze. The four disks in the picture are supposed to represent little compasses -- **draw** the direction that each compass should point.

Connect the circuit and use your compass to check your prediction – were you correct? If not, why not?

PART III: FORCE ON A CURRENT IN A MAGNETIC FIELD

Magnetic fields produce a force on any moving charge. This can be observed in the lab by moving charges through a wire (like with an electrical current). The **magnitude** of the force on a current-carrying wire in a magnetic field is given by

$$|F| = ILB\sin(\theta)$$

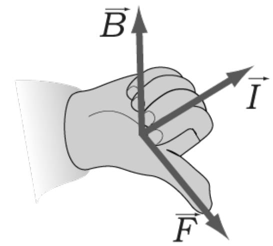
where F is the force on the wire, I is the current, L is the length, and B is the magnetic field, and θ is the angle between the direction of the current and the magnetic field direction. For example, if the current is perpendicular to the magnetic field, θ=90° and *sin(θ)*=1, so the magnitude of the force just equals ILB. The unit of measurement of magnetic field (*B*) is the **Tesla** (the earth's magnetic field is about 0.00005 Tesla).

Using the formula above, represent the unit Tesla in SI units N, A, and m.

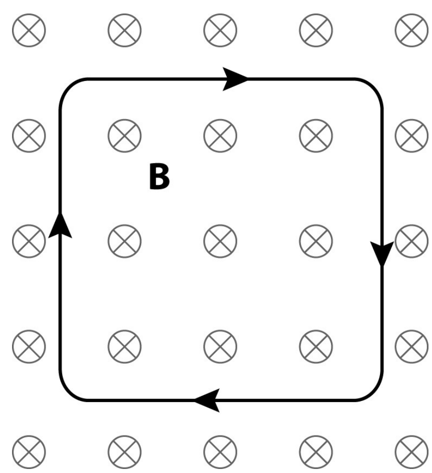
If a 10 cm long wire carrying 2 amps is ***parallel*** to the magnetic field lines of a 0.1 Tesla field, what is the force on the wire? Make a sketch to go with your answer.

Suppose you bent the wire into an "L" shape right in the middle, so that the two halves are at a right angle (90 deg) to each other. You orient the wire so one half it (5 cm) is parallel to the magnetic field, and the other half (5 cm) is perpendicular to the magnetic field. What will be force on this wire?

To figure out the **direction** of the force on a current from a magnetic field, you need to use another **right-hand rule** (note that this is the *second* way we use the right-hand rule for magnetism). To use this right-hand rule, aim your fingers towards the direction of current ($\vec{I}$, which is along the length of the wire) then curl your fingers in the direction of the magnetic field ($\vec{B}$). Now extend your thumb, which will point in the direction of the force ($\vec{F}$).

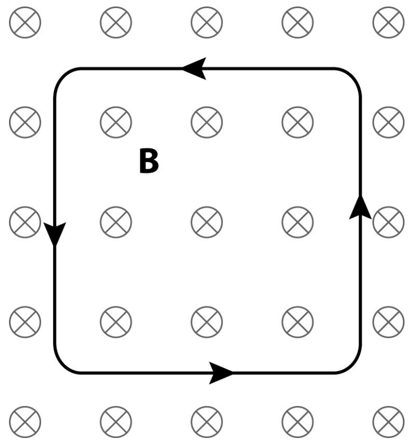


In the figure below, the magnetic field lines point into the page (as indicated by the little circle with the cross in it – that symbol is supposed to represent the view of an arrow shooting away from you). Current is running through the circuit as indicated by the arrows on the rectangular wire. On each side of the circuit, draw an arrow representing the direction of the force (use the right-hand-rule to figure out the direction).



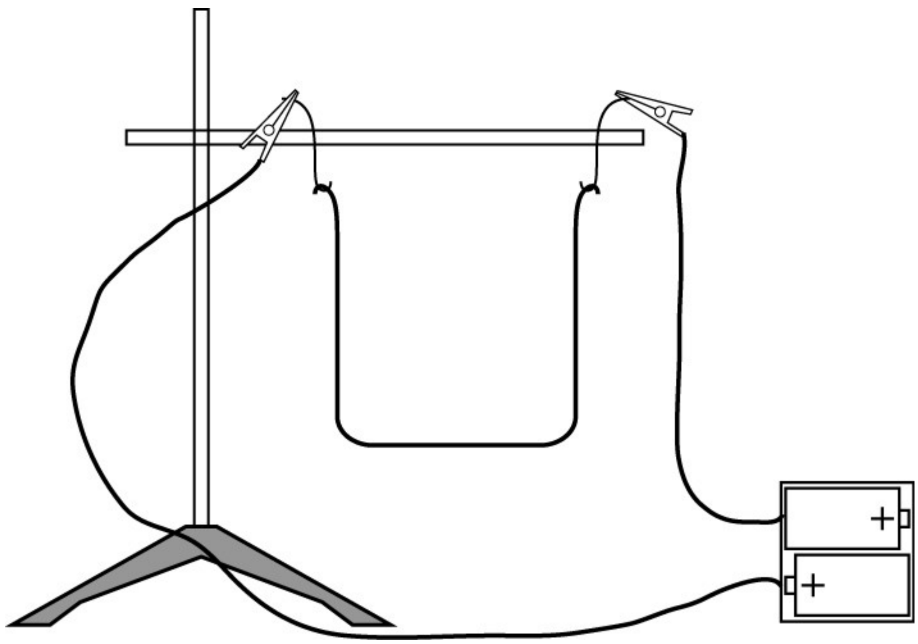
If this wire were flexible, what would happen to it?

Repeat the previous problem with the figure below, which is similar except that the current is now going in the opposite direction.

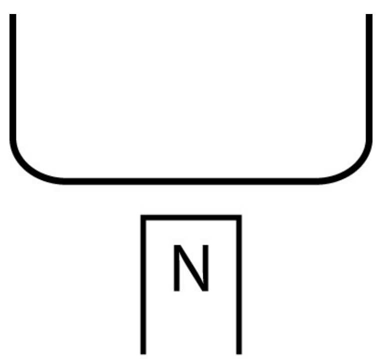


If this wire were flexible, what would happen to it?

On the figure below, draw the direction of the current.



The figure below is a zoom-in of the bottom of the trapeze as the end of the bar magnet is moved close to the trapeze. Re-draw the current direction, and now draw in the magnetic field lines from the bar magnet. Which way will the trapeze swing? (Will it swing at all?)



Hook up the circuit and try the experiment. Is your prediction correct? If not, why not?

Predict what would happen, if the other end of the magnet were used, then check your prediction – were you correct? If not, why not?

Predict what would happen if the battery was connected in the other direction, then check your prediction – were you correct? If not, why not?

PART IV: PUTTING IT ALL TOGETHER

Imagine you have a flexible wire with current running through it, bent into a kink as shown below. The current in each side of the kink will *produce* a magnetic field which *acts on* the current flowing through the other side.

Will these forces kink the wire up more or un-kink the wire?